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PRODUCTION OF ACALA COTTON IN THE SAN JOAQUIN VALLEY OF CALIFORNIA[1]

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CULTURAL CONDITIONS IN THE SAN JOAQUIN VALLEY

The San Joaquin is one of the largest of the interior valleys of California, being approximately 200 miles long and 30 to 40 miles wide. Lying between the Coast Range on the west and the Sierra Nevada Mountains on the east, it is protected from the cold breezes of the coast, but does not have the extreme desert temperatures of some of the interior valleys. In the greater part of the valley only occasionally does the last frost come after the first of April. November 1 may be considered the approximate date of the first killing frost in the fall, though frost sometimes occurs soon after the middle of October. Under normal conditions a growing season of seven months may be expected. During the summer there are many days of continued warm, sunny weather, with the maximum temperature averaging well above 90° and often more than 100° F. This valley differs from some of the other irrigated valleys of the Southwest in that the summer nights are considerably cooler. These climatic conditions are very well suited to the proper development of the

[1] The writer wishes to acknowledge his indebtedness to Fred W. Herbert, of the Bureau of Plant Industry, for valuable suggestions in preparing this bulletin.

cotton plant, and the valley represents one of the largest potential cotton-growing areas in California.

Cotton was grown in the San Joaquin Valley more than half a century ago, but the industry was abandoned after a few years on account of labor and transportation difficulties that made it impossible to compete with the production of short staples in the eastern Cotton Belt. The industry has now been reestablished on the basis of new cultural and community production ideas not originating in the eastern Cotton Belt but developed in this and other irrigated valleys of the Southwest.

With conditions of soil and climate in the San Joaquin Valley less extreme than in the other southwestern valleys where cotton is being grown, the cultural requirements are somewhat simplified. There is less difficulty in keeping the young plants from growing too large, but the same need exists of giving enough water after the fruiting stage has been reached. Undoubtedly one of the most important factors in simplifying the methods of production and promoting the establishment of cotton growing on a profitable basis has been the adoption of a single superior variety for the entire valley.

Circular No. 164, issued by the United States Department of Agriculture[2] in 1921, treated of the culture of Pima Egyptian cotton in the San Joaquin Valley, but since then the Acala variety of Upland cotton has been substituted and is now being grown to the exclusion of all others. The advantages of growing only one variety of cotton are being demonstrated in many ways and are greatly appreciated by the growers. Attention having been given to a single variety, the cultural problems are simplified, and farmers have become more skillful in handling the crop. This undoubtedly is a factor in the increased yields that are being obtained. The average acre yield has been increased from half a bale to a bale, and yields of 1½ to 2 bales per acre have become more common. At the same time, the fiber is more uniform and in greater demand by manufacturers. For this reason the growers in the valley have been receiving a premium of 1 to 4 cents a pound for their product above the current prices of Middling cotton. Cotton growing has been so profitable in the San Joaquin Valley for the last few years that the area planted has increased from 1,500 acres in 1921 to more than 36,000 acres in 1924, with an estimated acreage above 90,000 in 1925. With this has come an increased demand for information regarding the methods used in producing Acala cotton in this valley. Cultural methods which have proved well adapted to conditions there, including preparation of land, planting, thinning, irrigating, cultivating, etc., are described in this bulletin.

CHOICE OF THE ACALA VARIETY OF COTTON[3]

Choice of a variety is one of the first problems to be encountered, especially in districts where cotton is a comparatively new crop, as in the San Joaquin Valley. The only way to determine the variety

[2] W. B. Camp. Cotton Culture in the San Joaquin Valley in California. U. S. Department of Agriculture Circular 164, 22 pp., illus. 1921.

[3] Acala is a superior type of Upland cotton (*Gossypium hirsutum*) discovered in southern Mexico in 1906 by the United States Department of Agriculture and later acclimatized in Texas. Experiments were first made with this variety in California in 1915. The first commercial planting was made near Bakersfield in 1919.

best adapted to a particular district is by actually comparing for several seasons the different varieties under the local conditions. Such comparisons have been made in the valley for the last nine years by the United States Department of Agriculture. The result is that the Acala variety, a medium-staple Upland cotton, has proved well suited to the greater part of the valley, including Kern County northward to Turlock, and encouraging returns have been obtained from plantings in portions of the Sacramento Valley.

Other varieties of cotton, including Pima (Egyptian long staple), have proved to be exceptionally well adapted to this same district, but though Pima cotton was grown successfully in the vicinity of Bakersfield and Fresno for several years, 1918 to 1920, Acala is undoubtedly adapted to a wider area, including many outlying districts where some seasons might be too short for Pima. Acala in this valley seems to have a combination of superior qualities that can not be claimed for any other variety. (Fig. 1.) It is early, productive, with large bolls which open widely, so that picking is easy, and

FIG. 1.—First commercial field of Acala cotton in the irrigated valleys of the Southwest, grown near Bakersfield, Calif., in 1919

higher average yields are obtained than from the varieties that are being grown commercially in other regions. Acala seems better able to withstand adverse seasons or poor cultural conditions and still turn out a yield of good fiber heavier than any of the others. The fiber is of excellent uniform quality, measuring $1\frac{1}{8}$ to $1\frac{3}{16}$ inches under favorable conditions. In the San Joaquin Valley it has been in such demand by many of the mills that during the years 1923 and 1924 the growers have received premiums ranging from 1 to 5 cents per pound over ordinary short-staple cotton.

Since Acala does so well in the San Joaquin Valley, maturing as early and yielding as heavily as any other variety and at the same time selling for a higher price than ordinary short cotton, there appears to be every reason to continue growing this variety. There are, however, dangers which threaten one-variety community production. Many new settlers naturally wish to grow varieties with which they were familiar in Texas or other parts of the older cotton-producing areas. Nothing seems quite so alluring to the average

grower as an advertisement of seed of a new and wonderful cotton assuring enormous yields. Other varieties are selected and recommended solely on the basis of a very high lint percentage or outturn at the gin. Many growers mistake this to mean a larger yield of lint, but the yields of high-percentage varieties are often low.

ONE-VARIETY COMMUNITIES

After selecting the variety that is best suited to a district comes the even more difficult problem of establishing it to the exclusion of other varieties. This can be successfully accomplished only after public interest is aroused through the cooperation of various agencies, such as the public press, local agricultural authorities, and the more influential farmers. In the San Joaquin Valley the adoption of one variety has been brought about with most satisfactory results; the practical application of the idea in this valley has thoroughly demonstrated that only by such community action in producing but one variety of cotton is it possible to maintain pure seed of high quality. When more than one variety is grown in the same district cross-pollination occurs between the fields of the different varieties. Then, when the cotton is taken to the public gin the seed of two or more varieties is mixed and seed from fields of high-quality cotton is contaminated by that from run-down cotton. In a community where only one variety is grown all this mixing is prevented. With every cotton grower in the valley planting only pure seed of an improved strain of Acala neither cross-pollination nor public ginning can impair the inherent quality of the seed or lint.

The more intensive study of the production problems in connection with the one-variety community has reacted favorably both on the growing and subsequent handling of the crop. Growers are enabled to make more direct comparisons of the effects of soils or of cultural differences instead of being confused by varietal characteristics, so that improved methods are more readily appreciated and adopted. Growers are now recognizing that better prices can be obtained for a standardized product, and this, together with other advantages, has led to the adoption of a single variety for the entire valley. Having a standardized "unit" product to offer, the textile value increases, while the expense of classing and handling the bales in different lots is reduced.

There are advantages in relation to picking, because a more uniform scale of picking charges can be fixed, and with ginning also, because the machinery can be adjusted to a uniform length and quality of fiber, and frequent changes are not necessary, as is often the case with mixed varieties.

The classing of the bales is greatly simplified, and cotton of a known quality is made available to buyers in large quantities. The securing of State cotton classers for some of the larger centers in the valley has been facilitated. These classers grade and staple every bale of cotton offered, thereby furnishing a basis for more direct and intelligent dealing with responsible buyers. Competition is stimulated by the chance of securing large lots of even-running cotton. Buyers have come long distances to enter bids when large offerings were being made.

Not the least of the benefits accruing to the community in growing a single variety in the San Joaquin Valley has been the psychological effect upon those interested in the industry. The need of protecting the community against the introduction of new varieties brings the growers in closer relationship with each other, promotes their interest in other phases of production improvement, and tends to establish a more sympathetic contact with the local agricultural agencies. Also, the farmers do not waste money buying and experimenting with unproved varieties, nor are they confused by conflicting claims of competing seed dealers, who often make careless and exaggerated statements. It is natural that in an unorganized community there will be many innocent buyers of inferior seed.[4]

DEVELOPING SUPPLIES OF PURE SEED

As a direct result of the production of only one variety of cotton in the San Joaquin Valley there has come a more thorough knowledge of the plant characteristics of this variety. This, in turn, has led many of the more progressive growers to appreciate that careful selective breeding is necessary in order to maintain high standards of production. Pure-seed fields have been planted, rogued (fig. 2), and separately ginned, in order to supply an increased stock of superior planting seed for the community. Several of the gins have erected separate storage houses where cotton from pure-seed fields is stored until there are a sufficient number of bales for a full day's run. Certain days are designated as pure-seed days, and growers are notified accordingly.

Formerly it was necessary to catch the pure seed on the floor, just under the gin stand, instead of running it out through the screw

[4] While this circular was in course of publication, an act was passed by the legislature of California for the protection of one-variety cotton communities. The purposes of the act are stated in the caption and first section, as follows: "An act to provide for the growing of one variety or species of cotton, to wit, Acala, in certain prescribed and defined districts in the State of California; to prohibit the picking or harvesting of any variety or species of cotton other than that known as Acala in such districts; to prohibit the possession within such district for the purpose of planting any seeds or plants of any variety or species of cotton other than that known as Acala in such districts; to prohibit the ginning of any variety or species of cotton other than that known as Acala in such districts; defining such districts; and fixing the penalty for a violation of this act. SECTION 1.—The legislature hereby declares that the purposes of this act are to promote, encourage, aid, and protect the planting and growing of cotton in the State of California; that it believes this purpose best can be accomplished by restricting within certain areas hereafter defined the planting and growing of but one variety or species of cotton, to wit: 'Acala'; that by this means alone is it possible to bring the cotton-growing industry in the State to its highest possible development and to insure the growing of the most superior and economically most profitable variety or species of cotton; that the planting of pure seed is essential to the production of a more merchantable and better grade of cotton and cotton seed and for the production of a grade of fiber best suited for manufacturing purposes; that the planting of impure seed or plants other than that permitted in the areas hereinafter defined is an economical harm and loss to the planter thereof and an irreparable injury to the adjoining or neighboring growers; that the restriction of the use to which cotton lands may be used, as provided in this act, is essential to the highest development of the cotton-growing industry and of benefit even to one who would violate the provisions of this act; that it is essential that but one variety of cotton should be ginned in the districts in this act defined, otherwise the gin will mix the different kinds of seed, crossing takes place in the fields, the varieties are mongrelized and cease to be uniform, the fiber deteriorates in quality, and the seed rendered unfit for planting; that solely by restricting the growing of one variety or species of cotton in certain areas can the fiber be grown of uniform length and quality, and the highest price paid for the cotton thus obtained, and the production of fiber of different lengths or grades be prevented; that fibers of different lengths and grades are commercially inferior and when assembled in one lot or grade are classed and given the value of the lowest grade in the lot or sample; that Acala cotton is now the variety or species of cotton that has been most highly developed and improved and most suited commercially for growing in the districts in this act defined; that if future experiments should develop an improved variety or species of cotton, this bill can be amended to designate it; and that the districts in this act defined can be altered, restricted, or extended."

conveyor to become mixed with other seed. However, several gins in the valley are now equipped with a second seed conveyor, which is arranged so that it can be easily cleaned and permits its use for pure-seed purposes.[5]

The Farm Bureau of Kern County has taken a very active interest in placing the production of cotton on a one-variety basis in the entire county. Under the guidance of this body, different agencies have been organized to look after the proper production and safeguarding of the planting seed as well as to secure improvements in classing and marketing.

ACREAGE OF COTTON IN RELATION TO THAT OF OTHER CROPS

Many farmers make the mistake of planting too much cotton, as compared with the other crops which they are growing. Many have planted their entire acreage in cotton, thus making themselves dependent upon this crop for their annual income, which for several

FIG. 2.—A pure-seed field of Acala cotton receiving its first roguing. This is the operation of pulling out or cutting down plants that are off type and otherwise undesirable and is necessary for the purpose of supplying superior planting seed

reasons is bad practice and economically unsound. The water supply may prove inadequate, as the cotton crop needs heavy irrigations during July and August, whereas part of the land may be used for crops that will not require as much water in the summer. Farmers who plant only a part of their acreage in cotton usually exercise more care and give better attention to details, watch the crop more closely during the critical periods, pick their cotton cleaner, and receive better prices. With a small acreage of cotton grown in rotation with other crops, the grower is less dependent upon outside labor and in case of a period of low prices is able to carry his crop over until the market improves.

From the standpoint of the welfare of the community at large there is a real danger in placing too much dependence upon one crop. The fact that bankers in some sections do not favor lending money on cotton unless the farmers agree to put in part of their land to other crops indicates the emphasis that financial interests place upon diversification. Periods of low prices for cotton cause

[5] The pure-seed conveyor was designed by James S. Townsend, Associate Technologist.

greater distress in districts where most of the farmers plant so large a part of their land to cotton that they become practically dependent upon this one crop.

SELECTION OF LAND

Soils that will grow good crops of alfalfa and other deep-rooted field crops will grow good cotton. A medium-sandy loam is the ideal type, since it is more easily worked and absorbs and holds water better, though large yields have been obtained from sandy and heavy land. Cotton will stand a small amount of alkali, but good crops are not to be expected from alkaline or hardpan soils. Where hardpan is less than 3 feet from the surface the roots do not develop normally, and water is required more frequently.

On good land when the plants are well grown the bolls are larger and open more widely, so that picking is easier, and the fiber is of better and more uniform quality. Some farmers have the idea that land which has been in alfalfa or pasture for several years should not be planted to cotton, because the cotton may grow too large and fail to open its bolls before frost. Although this sometimes occurs on rich land with a high water-holding capacity, the highest yields of cotton in the San Joaquin Valley have usually been obtained from fields previously in alfalfa or other leguminous crops. The use of cowpeas, vetches, and melilotus has increased rapidly in the last few years. Ordinarily, less water is required to grow a crop of cotton on rich alfalfa land; for this reason greater precaution is necessary in applying irrigation to avoid too luxuriant growth.

COTTON IN YOUNG ORCHARDS AND VINEYARDS

In many districts cotton is being regularly grown as an interplanted crop, especially in young orchards and first-year vineyards. Many instances can be cited where growers have planted two rows of cotton between rows of young vines or four to six rows between rows of trees, and remarkable results have been obtained. Yields of a bale to the acre are of common occurrence, and 1½ to 2 bales have been reported from many interplanted fields. Thus, the cotton not only gives a very profitable return but in many instances insures more careful cultivation and irrigation, which benefits the young vines and trees. The returns from the cotton have made it possible for many farmers to establish themselves in the fruit industry in the San Joaquin Valley.

NEED OF THOROUGH LEVELING

More important than selecting a particular type of soil is the necessity for having the land properly leveled. The exact slope or grade to be used in leveling, sometimes referred to as the lay of the land, will depend somewhat upon the type of soil, a steeper grade being possible on the lighter soils where water is readily absorbed. For the best results the land should be nearly level, because then the control of irrigation water is an easy problem and at the same time less water will be required than on land having a steep slope. In the San Joaquin Valley nearly all irrigation water for cotton is pumped,

so that small heads of water are carried in furrows, which makes it less important that the land be uniformly leveled in more than one direction. But this at least must not be neglected, or satisfactory control of irrigation water is out of the question. With imperfect leveling the soil is likely to dry out, so that seed may fail to germinate in some parts of the field, or the plants may be stunted by drought; at the same time, other parts of the same field may be overwatered, which causes a too luxuriant growth of the plants, later opening of the bolls, greater damage from frost, and more difficult picking.[6] Even when good stands are established, the fields that are not properly leveled will dry out in spots during the summer; and, in order to avoid reduction of yield and injury to quality, it becomes necessary to irrigate these spots separately, thereby causing much extra expense for water and labor.

PREPARATION OF LAND

The preparation of land for cotton depends largely upon what crop was grown the preceding year.

In preparing land which was previously planted to milo it is best to plow it early in the fall or winter, covering the old stalks several inches deep. It is not necessary to harrow at this stage; in fact, it is best to leave the soil in the rough, to absorb the rain that falls during the winter and spring, then just before planting time to irrigate so as to saturate the soil thoroughly. It is unnecessary to plow again before planting; else the soil will dry out too deeply. A disk harrow is preferable on the heavier types of soil; but on the sandy soils a spring-tooth harrow (fig. 3) seems to give very satisfactory results, in that it does not stir the soil to too great a depth. A firm moist seed bed is highly desirable.

Many farmers find it rather difficult to grow cotton on land that has previously been in alfalfa, if the alfalfa roots are not killed before planting the cotton. Fairly good results in destroying the roots have been obtained by either of two methods. One is to disk and then cross-disk the alfalfa stubble and after a few days follow with a big plow, turning the stubble completely under. The land should then be allowed to lie with the alfalfa roots exposed to the sun for a few weeks before watering. Another method is to plow the land 2 or 3 inches deep in the fall, allowing the roots to be exposed to the sun and frost, and then to cross-plow in the spring to a depth of 6 or 7 inches.

Land that was previously planted to cotton should be prepared just as soon as the crop is harvested, though this is often not until January. A stalk cutter should be used to chop the stalks into small pieces; then the land should be plowed to a depth of 6 or 8 inches, completely covering all the plant material so it will not interfere with further cultivation. Irrigation may be applied at any time during the winter, because water can be stored in most of the soils of the San Joaquin Valley. However, it must be remembered that a thorough irrigation is necessary just before planting time to wet the soil to a depth of 4 or 5 feet and store as much water as possible

[6] C. S. Scofield and others. Production of American Egyptian Cotton. U. S. Department of Agriculture Bulletin 742, 30 pp. 1919.

for the summer requirement. Further preparation is performed with a disk or spring-tooth harrow followed by a drag or smoothing harrow, leaving a well-pulverized seed bed. Planting should follow as soon as practicable, so that the seed can be placed in a well-moistened soil. Too much emphasis can not be laid upon the importance of preparing a good seed bed. All the work done during the winter and spring in leveling, plowing, and irrigating will be more than repaid during the following season, as it will require less labor and expense to care for the crop, and the yield is certain to be larger.

PLANTING AND GERMINATION

In most of the San Joaquin Valley planting should be done during April or as soon as possible after the danger of spring frosts is past. Fairly good results have been obtained from cotton planted as late as May 20, but success depends on a long season, and risk increases the later the planting is done. Early planting is desirable not only to obtain the advantage of the longer season but because the young

FIG. 3.—Preparing a seed bed for cotton with a spring-tooth harrow

plants are likely to show more normal habits of branching and fruiting if hot weather is not encountered during the early stages of growth.[7]

Satisfactory results may be obtained with either a 1-row or a 2-row planter (figs. 4 and 5), though the latter is preferable, because a more uniform depth of planting can be had. Other advantages are the saving of time and the making of straight rows, which are essential for the most efficient cultivation.

To insure a good stand of cotton it is advisable to use 20 to 30 pounds of seed to the acre. Under ordinary conditions 25 pounds will give satisfactory results. Some growers plant only 12 to 15 pounds of seed, and a few get fairly good stands, though most of them probably would obtain better yields by planting more seed. Planting the larger quantity of seed has two important advantages. One is that there are more seedlings to help break any crust which may form on the surface, and the other that a better stand permits

[7] See footnote 6.

more regular spacing, even when some of the seedlings are destroyed by disease or insects.

Many farmers in the San Joaquin Valley space their cotton rows 4 feet apart, and some of the best fields have been grown in this way,

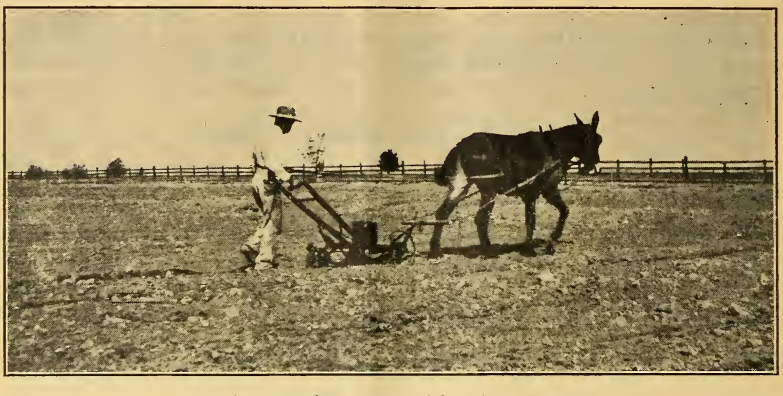

FIG. 4.—Planting cotton with a 1-row planter

but on the lighter and less productive soils 40 to 44 inches is sufficient. The wider rows permit the sunlight to reach the ground even when the plants grow rather large, as is usually the case on fertile soil with plenty of water. The desired number of plants per acre can be maintained by leaving them closer together in the row.

Attention should be called to the importance of planting only the very best seed. Farmers should first make sure that the stock

FIG. 5.—Planting cotton with a 2-row planter, showing the slight furrow made by the shoe attachment illustrated in Figure 6. Note the marker to keep rows straight

of seed is pure, that is, not crossed or mixed with other varieties of cotton, and then should give attention to the maturity and cleanness of the seed. Seed from cotton that was damaged by frost should not be used for planting, as the percentage of germination is low. It

is often advisable to reclean or delint much of the seed for planting; this, however, depends largely upon the efficiency of the ginning.

Flat planting is to be recommended for most soils, using a special shoe or lister attachment (fig. 6) to push away dry soil and reach a moist seed bed. This device is very simple and easily made either of wood or iron. It fits over the original planter shoe and is readily adjusted so as to allow the seed to be covered to a uniform depth. The loose dry surface soil is pushed aside and the seed placed in moist earth.[8]

In cases of extremely heavy soil it is sometimes advisable to plant on a ridge thrown up with a lister. Just before planting, water

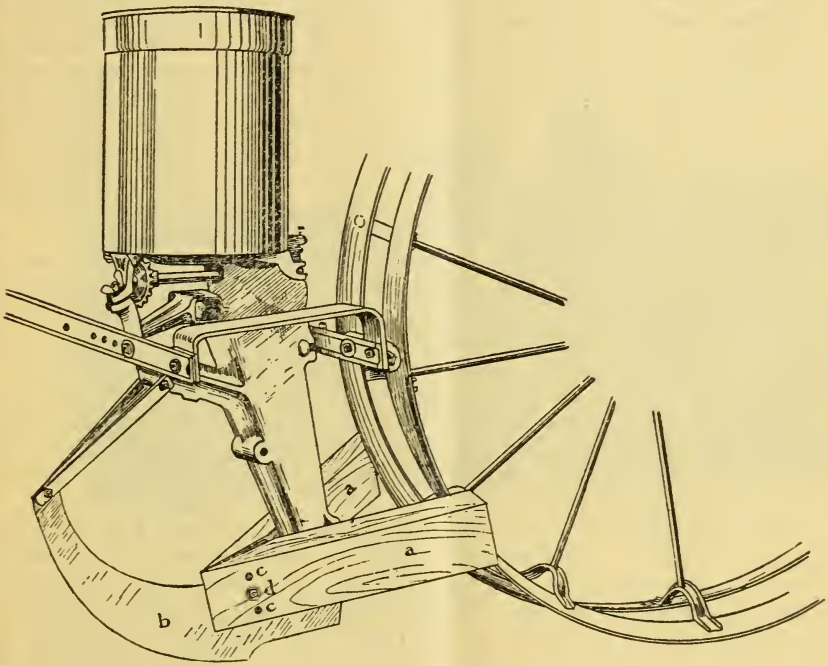

FIG. 6.—A planter attachment used to push away the dry surface soil: *a*, *a*, The 2 by 4 wings; *d*, bolt used to fasten the wings to the shoe. Additional holes (*c*, *c*) can be put in the wings, so that they may be lowered or raised as desired, and the depth of covering the seed may be regulated in this way

should be run between the rows to moisten the ridges by subirrigation. The tops of the ridges are then smoothed off with a heavy board, so that the seed can be planted in moist soil. This method permits a subsequent irrigation without flooding water over the tops of the rows, and the formation of a crust is avoided.

In some districts of the San Joaquin Valley having very sandy soils many growers plant in the bottom of a lister furrow, thus placing the seed in firmer and moister soil and avoiding some of the dangers from drying winds, which often occur at planting time.

[8] S. H. Hastings. A Lister Attachment for a Cotton Planter. U. S. Department of Agriculture, Bureau of Plant Industry, Crop Physiology and Breeding Investigations [Circ.] 2, 3 pp., illus. 1917.

This method is also used in places to overcome the difficulties of uneven land, the furrows being sufficiently deep to carry water through the high places and supply moisture to the plants. This method, however, is not recommended for heavy lands or for other soils where flat planting is practicable.

A special planting problem is often encountered with soils that dry out so quickly that even in a day or two of drying weather there may not be sufficient moisture left to germinate seed placed in the upper inch or 2 inches of soil. Also, care must be exercised to avoid a crust, which forms on many of the soils as a result of pressure from the planting tool. Practically all the commercial planters used in the San Joaquin Valley are equipped with a type of runner shoe which in opening up the soil often compacts and glazes the sides of the furrow. Under such conditions the wheel that follows the shoe does not close the furrow properly, but leaves a narrow open track of packed earth along the middle of the furrow, which allows the soil around the seed to dry out rapidly. Even where no groove is apparent on the surface, investigation may show that the pressing of the soil, especially if a little too wet, has closed the groove at the surface but has left a hollow channel underneath, so that the seeds do not have sufficient contact with the soil to start germination.

In such soils it is best to open the planting furrow with a small 2½ or 3 inch shovel which runs behind a larger furrower or other attachment for pushing aside the clods and dry soil. Thus, the seed drops into the small furrow and is covered from the sides by two other small shovels or a similar arrangement followed by a chain or drag which tends to firm and smooth the seed row without actually packing it, at the same time leaving a slight mulch. Where this method is used, it has been found that the seed can be covered somewhat more deeply with the loose surface soil, which is a further advantage in protecting the seed in these fast-drying soils.

Under normal conditions the seed should be covered 1 to 2 inches deep. If other conditions are favorable and the soil rather heavy 1 to 1½ inches may be sufficient, but on the average type of sandy-loam soil found in the San Joaquin Valley 1½ to 2 inches is better. It should always be borne in mind that the seed must be placed in and covered with moist soil so as to insure prompt germination. With the shoe attachment this is an easy matter. Under no condition, however, should the seed be covered more than 2½ inches, lest the young seedlings may be unable to push through. Every year much loss is suffered in the valley by planting too deep. Many fields have to be replanted, and in others the yields are seriously reduced by not obtaining a uniform stand. The same is often the case when the seed is not covered deeply enough or is planted in dry soil. Flooding the land after planting in order to germinate the seed is not advisable, because even in sandy soils a crust usually forms and it is very difficult for the young plants to break through.

The importance of having sufficient moisture in the soil to insure proper germination is fully appreciated by many farmers. One ingenious grower has devised a special 10-row planter equipped with a large portable water tank for wetting the soil in the seed furrow. The water from the tank is conducted through a hose pipe to the

planter, with a ¾-inch faucet below each seed hopper, so that the water runs down the seed spout with the seed, thereby wetting the soil into which the seed falls.

CULTIVATION

Cultivation should begin as soon as the plants are well out of the ground, so as to break any crust which may have formed, to allow the soil around the young plants to warm up, and to kill the weeds. The first cultivation should be shallow, because the San Joaquin Valley soils will usually dry out as deeply as they are stirred. It is often possible to make the first cultivation with a drag or spike-tooth harrow, thus saving a great deal of time and labor. A disk cultivator (fig. 7) is also found very satisfactory for the first one or

FIG. 7—The sled, or go devil, type of disk cultivator. This implement is very satisfactory for making the first cultivation where cotton has been planted in a furrow

two cultivations, especially on trashy land, but small shovels and sweeps are better for the later cultivation, because they will kill more weeds and at the same time leave the land in better condition for irrigation and the following cultivation.

Just as soon as the plants have reached a sufficient height so that there is no danger of their being covered, the soil should be gradually worked toward them at each cultivation, in order to cover any weeds that may appear in the row and at the same time throw up a small ridge along the rows. This makes it easier to control the subsequent irrigations and furnishes support for the cotton plants late in the season. The ground should be stirred, of course, after each irrigation until the plants are too large to be cultivated. More frequent cultivation may be necessary in many fields to keep down weed growth and maintain a good mulch on the surface. This is especially true early in the season when irrigations are likely to be several weeks apart. On soils that do not subirrigate readily the water should be applied through two small furrows between the rows instead of through one center furrow. The small furrows should be made as close to the plants as possible.

A riding cultivator will be found more convenient up to the time when the plants are too tall, when a one-horse walking cultivator must be used. These late cultivations should also be shallow, so as not to interfere with surface roots.

THINNING AND SPACING

Thinning should not be done before the plants are 4 or 5 inches tall. This allows them to become well established and at the same time furnishes mutual protection against wind and sand storms. There is less danger of losing a stand from sore-shin or insect injuries and a better opportunity to eliminate the weaker or inferior plants.

Some of the best farmers in the San Joaquin Valley pull the plants by hand and believe that this is the ideal way to thin cotton, as it offers a better opportunity of leaving the best plants, avoids injury to the plants, and assures a more regular stand than can be had by chopping. However, this method is not considered practicable on large plantings, and a common hand hoe is generally used. Where the plants are to be left 12 inches apart, a 10-inch hoe is used; and, if the plants are to be spaced 8 inches, a 6-inch hoe is used.

During the season of 1924 one farmer in the valley harvested more than 300 bales of Acala cotton from a planting of 200 acres. The plants were spaced 6 to 8 inches apart in the row. The chopping was done with a 6-inch hoe made by cutting 2 inches off each side of a 10-inch hoe. No particular attention was paid to the exact distance between the plants, nor was much time lost in trying to reduce the stand to exactly one plant in each hill. For this reason the cost of thinning this particular field was only about $1 per acre, as compared with an average cost of about $1.50.

The general practice in the valley is to thin the plants when they are about 4 to 6 inches tall, leaving them from 10 to 14 inches apart in the row, but closer spacing is being used to an increasing extent. Several large commercial plantings in recent years have shown that a spacing of 8 to 10 inches in the row gives excellent results.

Very high yields have also been obtained in the valley from fields that had little or no thinning. Experiments in the Coachella Valley [9] and recent experiments at the field station at Shafter with Acala cotton spaced at 2 inches, 6 inches, 12 inches, and two plants at 12 inches have shown that under normal conditions there is not a great deal of difference in total yields, though the yields from the closer spacings of the very late plantings were slightly higher. Late-planted cotton grows much faster and more vigorously than cotton planted early, and for this reason there is greater need of restricting the size of the plants by leaving them closer together in the rows.[10]

The type of soil, however, may be a factor in determining the proper spacing. On very rich alfalfa land the plants should not

[9] H. G. McKeever. Spacing Experiments with Acala Cotton in Southern California. *In* Journal of Agricultural Research, vol. 28, pp. 1081–1093, illus. 1924.

[10] O. F. Cook. A New System of Cotton Culture. *In* U. S. Department of Agriculture, Bureau of Plant Industry Circular 115, pp. 15–22. 1913.

——— Single-stalk cotton culture. U. S. Department of Agriculture, Bureau of Plant Industry [Document] 1130, 11 pp., illus. 1914.

R. M. Meade. Single-Stalk Cotton Culture at San Antonio. U. S. Department of Agriculture Bulletin 279, 20 pp., illus. 1915.

be thinned until they are about 8 inches tall (fig. 8), especially if they are to be spaced 12 to 14 inches in the row, which many farmers believe to be necessary under such conditions.

SPRING AND SUMMER IRRIGATION

Since the need of irrigation depends upon the soil and climatic conditions, it is impossible to give any set rules stating when and how often to irrigate cotton. It is possible, however, to state a few principles which can be applied to most soils in the San Joaquin Valley.

As noted earlier in this circular, the soil should be thoroughly moistened before planting time; then under normal conditions on the average soil it will not be necessary to irrigate again for several weeks, or before the plants are several inches high. An advantage is gained if it is possible to supply sufficient moisture to

FIG. 8.—Acala cotton plants on very fertile soil, showing their size at thinning time

carry the young plants beyond the stage when an irrigation might wash out or otherwise injure very young and tender seedlings. Injury from Rhizoctonia, or sore-shin, a disease which affects the stems of the plants, is more likely if water is applied directly against very young plants during the colder weather of spring, when the surface soil does not dry out quickly. If the irrigation that is given before planting can take care of the water requirement until warm weather sets in, there is less danger from this source. In many instances, however, water is needed when the plants are only 2 or 3 inches high. (Fig. 9.) This is especially true on light sandy soils after a hot drying wind, which may dry out the soil below the young taproots; but, after the roots have become well established, it is desirable to withhold water as long as possible without actually stunting the plants, especially on rich soil where there is danger of overluxuriant growth. Very little cotton in the valley has been damaged by overirrigating during the summer months, and there is

less danger of rank growth than in the hotter valleys of California and Arizona. Much of the land in the valley is sandy, which provides good drainage, and the cooler weather has a tendency to hold back or restrict the vegetative growth of the plants, though allowing early and regular development of fruit.

On some of the soils in the San Joaquin Valley having a high water-holding capacity crops of cotton have been grown with only one or two irrigations, and others having a high water table have gone through an entire season without a single irrigation. On the other hand, the lighter and more open soils may require an early irrigation, and water may be needed as often as every week or 10 days during the height of the growing and fruiting season. (Figs. 10 and 11.)

Neither the character of the soil, the apparent amount of moisture in the surface soil, nor the number of days since the last irrigation gives a definite indication of the need of water. The condition of the plants must be the guide. Irrigation is not required so long

FIG. 9.—Field of young cotton where early irrigation was necessary, owing to light soil and drying winds. Note the double-furrow method of applying water

as the plants are growing vigorously. Lack of water is indicated by the wilting or drooping of the leaves in the hot hours of the day. A slightly wilted effect on a very hot day does not necessarily show the need of water, especially if the hot weather comes on somewhat suddenly after a period of cool weather. When the change from cool to hot weather is very abrupt and the difference between day and night temperature is great, the plants may require two or three days to adjust themselves. Rather severe wilting under such conditions has occurred in past seasons, and some farmers became panic-stricken even to the extent that many acres of good cotton were plowed up and reseeded. That this was an unnecessary expense and loss was shown on other fields similarly affected which recovered completely and produced more than the replanted areas.

After flowering begins, which will ordinarily be late in June or early in July, the plants should not be allowed to wilt to any great extent. It is then that the plants begin to use the maximum quan-

tity of water; and, after they need an irrigation, neglect for only a few days may result in serious loss from the shedding of young bolls. Careful observation will show that the color of the foliage in the dry spots appears somewhat darker, with a slightly bluish tinge, so that cotton in need of water can be recognized even from a distance. This slight change in appearance is noted even before the plants show signs of wilting and should be a definite warning that water is needed. If cotton suffers for water in July or August, the entire crop is likely to be affected both in yield and quality of staple. In addition to the blasting of buds, the bolls are not fully developed and do not open well, which makes picking more difficult (fig. 12).

LATE IRRIGATION

It is a mistake to neglect irrigation during the latter part of the growing season. If in viewing the field the flowers are seen to be

FIG. 10.—Irrigating by means of a broad shallow furrow. This method does not provide thorough wetting of the row except in soils that subirrigate readily. The rows should be long, to allow time for the water to spread laterally as much as possible

prominently exposed in the tops of the plants, it is an indication that irrigation has been postponed too long. The above rule holds good in the San Joaquin Valley until the middle of September, and even after that date the plants should not be allowed to wilt for lack of water. Vigorous growth is not desirable after the first of September and water should be used sparingly, but enough should be applied to keep the plants in a healthy condition and to take full advantage of favorable weather for maturing as many bolls as possible. Lack of water may force an earlier opening of some of the bolls, but it is not desirable to make plants wilt or the lower leaves wither and fall. This is too severe a check and will injure many of the bolls by forcing them to open prematurely, thus impairing the quality of the lint as well as causing buds and young bolls to shed.

The prevailing idea that water should be withheld from cotton, regardless of soil and climatic conditions, after the 1st of Septem-

ber, in order to make the bolls open, does not lead to the best results. It is true that if no more water is given after this date, a picking can ordinarily be made somewhat earlier; if the plants have been allowed to suffer, however, the top crop of bolls will not open normally but will be poorly developed and shriveled, which makes picking difficult and the fiber inferior. It is often desirable to irrigate once and sometimes twice after the first picking.

In case of very rank plants, especially on the heavier types of soil, more care should be used in applying the late irrigations, for if an excess of moisture is stored in the soil it will cause the bolls to be later in opening, and those nearest the ground may mildew or rot. It should be remembered that the soil and climatic conditions govern to a large extent the number of irrigations to be given during the growing season and also determine how late water should be applied. Also it must be kept in mind that bolls that are set after the first of September are in danger of being killed by early frosts in short sea-

FIG. 11.—Irrigating cotton by means of flooding. This method is used extensively on sandy and medium-type soils, but it should not be practiced on heavy or adobe soils. On such soils the furrow system is better

sons. Early in the season only 25 to 30 days may elapse between the square and the flower and only 42 to 50 days between the flower and the open boll, whereas with late bolls the period from flower to open boll is much longer, often 70 to 90 days. A supply of moisture must be maintained in the soil, in order to produce normal development and opening of the bolls.

Care in irrigation results in a normal healthy growth of the plants, from which a maximum yield may be expected. Underirrigation often makes the plants more susceptible to diseases or attacks by insects that may not be at all serious if sufficient soil moisture is available. In the San Joaquin Valley cotton is sometimes attacked by thrips, but the plants seem to suffer very little if they have plenty of moisture and are kept in a vigorous growing condition. If the fields are allowed to get too dry, however, and the plants suffer for water while the thrips are present, great damage may result. The early stages of the infestation may be detected by a gradual discoloration and curling of the edges of the lower leaves, caused by the

insects sucking and killing the cells of the lower surface of the leaves. The field takes on a silvery gray appearance, and as the infestation becomes more severe the leaves turn brown, growth is stopped, and the bolls open prematurely. Under drought conditions the injuries increase rapidly, commencing on the under side of the lower leaves, working upward, and soon covering the entire plant.

Observations extending over several seasons have shown that most of the thrips damage to cotton plants in the San Joaquin Valley has been in fields where the plants were known to have suffered for water. During the season of 1924 cotton grown on several experimental plats at the United States Cotton Field Station, Shafter, Calif., was severely damaged by thrips. It was noticed that the plants were affected where the ground was trodden hard and water did not penetrate, while the plants in adjacent plats where the soil was not packed did not show thrips injuries.

Thrips may continue to work after a water shortage has been corrected, but this does not mean that a lack of water was not the pre-

FIG. 12.—A well-grown field of Acala cotton, August 23, 1924. Note the uniformity of the plants

disposing factor in causing the damage, because the plants may have reached such a weakened condition that they could not further withstand severe attack. It appears that if precautions are taken to supply sufficient moisture to keep the plants in a vigorous condition they will be less susceptible to injury by this insect.

PICKING METHODS AND COSTS

Cotton differs from many farm products in being less perishable and does not have to be harvested as soon as the bolls are open. However, to get the best results, picking should begin just as soon as enough cotton is open to enable the pickers to make a living wage, which is when there are five or six open bolls on each plant with a spacing of 12 inches. Picking sometimes begins in the fore part of September, but many late-planted fields are not ready to pick until the middle of October.

Each picking should be kept separate, because marked differences may be found when the grading is carefully done. Three pickings

are usually made. To receive the highest grade and thus command the best price, careful picking is necessary, for the cotton must be kept as clean as possible from leaf and dirt trash. The late pickings usually contain more broken leaves and other particles of trash, which tend to lower the grade. Also cotton picked after frosts have occurred is likely to contain much immature fiber, which is weak and of inferior grade. Frosted cotton should not be mixed or ginned with the earlier pickings. After a freeze occurs, the field should be gone over as soon as possible before the frosted bolls open. If fiber from frosted bolls is included with the good cotton the lowering of the grade may occasion serious loss.

Light frosts late in the season may do no damage to the bolls and often prove an advantage, especially in rank cotton where the foliage is so dense that the sunshine can not reach the lower bolls. The leaves drop off and allow the sunshine to reach the bottom of the plants, so that the bolls open more rapidly. (Fig. 13.)

FIG. 13.—Field of an improved strain of Acala cotton in the San Joaquin Valley which yielded 2.6 bales per acre. Note the number and size of the bolls

Poorly grown cotton or cotton which has suffered severely for lack of water should also be picked and ginned separately, to avoid injuring the grade of the better fiber. Good pickers may average more than 250 pounds a day in well-grown fields of Acala cotton; in exceptional cases more than 400 pounds have been gathered by experienced pickers.

Most pickers prefer large sacks, which are usually about 30 inches wide and 9 to 12 feet long. These bags have a wide strip, or band, which passes over the picker's shoulder. On account of the length of the sack the weight rests upon the ground, and the sack is dragged rather than carried to the ends of the rows. (Fig. 14.)

Cotton should never be piled on the ground or left exposed in the field. (Fig. 15.) It is safer and much more convenient to dump it directly in the wagon, so that it may be hauled to the gin without a second handling. Where this is not possible it should be housed in a dry place. Light rains do very little damage, but heavy rain on cotton piled in the field may stain the fiber several inches deep and

cause serious injury. Wet cotton should not be picked, but if the cotton is only a little damp from a heavy fog or dew, picking can proceed, provided the cotton is spread out in the sun to dry before being tramped down in a pile. If thoroughly dry, seed cotton can be stored indefinitely without danger of heating.

Since the adoption of only one variety of cotton in the San Joaquin Valley, growers have been able to set a more uniform price for picking, the entire valley adopting the same rates to be paid for the different pickings. During the past year this price was 1¼ cents per pound of seed cotton for the first picking and 1½ and 2 cents for the second and third pickings, respectively.

FIG. 14.—Pickers using long picking sacks. Much of the time the pickers crawl on their knees, special knee pads being worn

It is a practice among some farmers to glean the "bollies" (immature frosted bolls), but this is seldom profitable except in times of exceptionally high prices.

PRECAUTIONS IN GINNING

In order to obtain the highest commercial grades care must be exercised in ginning. Even though the cotton is well grown and every precaution taken in picking, much still depends on the gin to give the desired quality. J. S. Townsend, in charge of cotton-gin investigations for the Bureau of Plant Industry, and other gin experts advise that in order to turn out a first-class sample from a superior variety of cotton like Acala it is necessary for the gin saws to be run at a much slower rate of speed than is customary with ordinary short cotton. A loose seed roll also is very important. Wet or damp cotton gums up the saws and can not be ginned properly. This makes it very important that the cotton be dry before being delivered to the gin. If these practices are not followed, some of the fibers will be cut and napped, causing much waste and a lower grade.

During the season of 1924 it was found that some of the gins in the San Joaquin Valley were consistently turning out poor cotton, against which the buyers were discriminating. Investigation revealed the fact that these particular plants were running the gin saws at a very high speed, and the staple was being badly cut and damaged. Just as soon as this speed was lowered the cotton improved to a marked degree.

Ginners throughout the valley are much pleased over the fact that only one variety of cotton is grown in the community, as it greatly simplifies ginning. In mixed-variety communities the ginner must frequently adjust his machinery to suit the particular type of cotton that is being ginned; but since all the growers in the San Joaquin Valley are planting the same variety this frequent adjustment is not required and a more uniform product can be turned out.

With only one variety of cotton in the valley, the ginners have been able to adopt a more uniform charge for ginning. For the

FIG. 15.—Cotton piled on the ground and left in the field. Dirt and trash are accumulated by this wasteful method of handling, and in case of rain the cotton may be wet several inches deep

seasons of 1923 and 1924 the price has been 30 to 35 cents per 100 pounds of seed cotton, with an additional charge of $1.50 to $2 a bale for bagging and ties. Also there is ordinarily an insurance and yard charge of about 75 cents per bale, which makes the total cost of ginning a 500-pound bale of cotton about $7 or $8.

CLASSING AND MARKETING

One of the evidences of the rapid and marked improvement brought about in the cotton industry of the San Joaquin Valley through the production of but one variety in a community is seen in the facility with which the staple is marketed. Already organized for the purpose of growing Acala cotton only, the farmers took another step forward in the interest of obtaining the fullest possible value for their product. In Kern and Fresno Counties, through their farm bureaus, the growers petitioned the California State department of agriculture to secure the services of cotton classers.

The duties of the classer have previously been described in this circular. Working under the jurisdiction of the State department of agriculture, the classer functions solely on the basis of his technical knowledge of cotton staples and grades and serves as an unbiased judge for both the producer and buyer. The farmer is informed of the exact length and grade of his fiber, so that he may receive a just and commensurate return, and the buyer is assured of obtaining cotton of known quality.

In conjunction with the cotton-classing service, selling agencies have been organized in some districts. Through these the larger lots of cotton are sold, affording a convenience for both seller and buyer. By reason of the classing service and the selling agency, cotton has been sold at an increase of 1½ to 3 cents a pound over that of a similar grade sold independently in the local yard on the same day. The State classer's certificates, showing the grade and staple of each bale, are submitted to the buyers, who usually accept them and enter bids without seeing the bales or the samples.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

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